IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Express Mail No.: EL067144355US
In re application of:. Peter SLADEN   **Group No.:**
Serial No.: 0   /
Filed: Herewith   **Examiner:**
For: IMAGE SENSOR

Commissioner of Patents and Trademarks
Washington, D.C. 20231

TRANSMITTAL OF CERTIFIED COPY

Attached please find the certified copy of the foreign application from which priority is claimed for this case:

Country   : **United Kingdom**
Application Number   : **9828544.8**
Filing Date   : **23 December 1998**

WARNING: "When a document that is required by statute to be certified must be filed, a copy, including a photocopy or facsimile transmission of the certification is not acceptable." 37 CFR 1.4(f)(emphasis added.)

Reg. No.: 24,622

SIGNATURE OF ATTORNEY

Clarence A. Green

Tel. No.: (203) 259-1800

Type or print name of attorney

Perman & Green, LLP

P.O. Address

425 Post Road, Fairfield, CT 06430

NOTE: The claim to priority need be in no special form and may be made by the attorney or agent if the foreign application is referred to in the oath or declaration as required by § 1.63.

(Transmittal of Certified Copy [5-4])

The
Patent
Office

INVESTOR IN PEOPLE

I, the undersigned, being an officer duly authorised in accordance with Section 74(1) and (4) of the Deregulation & Contracting Out Act 1994, to sign and issue certificates on behalf of the Comptroller-General, hereby certify that annexed hereto is a true copy of the documents as originally filed in connection with the patent application identified therein.

I also certify that the attached copy of the request for grant of a Patent (Form 1/77) bears an amendment, effected by this office, following a request by the applicant and agreed to by the Comptroller-General.

In accordance with the Patents (Companies Re-registration) Rules 1982, if a company named in this certificate and any accompanying documents has re-registered under the Companies Act 1980 with the same name as that with which it was registered immediately before re-gistration save for the substitution as, or inclusion as, the last part of the name of the words "public limited company" or their equivalents in Welsh, references to the name of the company in this certificate and any accompanying documents shall be treated as references to the name with which it is so re-registered.

In accordance with the rules, the words "public limited company" may be replaced by p.l.c., plc, P.L.C. or PLC.

Re-registration under the Companies Act does not constitute a new legal entity but merely subjects the company to certain additional company law rules.

Signed

Dated 3 0 SEP 1999

CERTIFIED COPY OF
PRIORITY DOCUMENT

An Executive Agency of the Department of Trade and Industry

(Rule 16)

Request for grant of a patent

(See the notes on the back of this form. You can also get
an explanatory leaflet from the Patent Office to help
you fill in this form)

THE PATENT OFFICE
23 DEC 1998
RECEIVED BY HAND

24DEC98 E414397-1 D02716
P01/7700 0.00 - 9828544.8
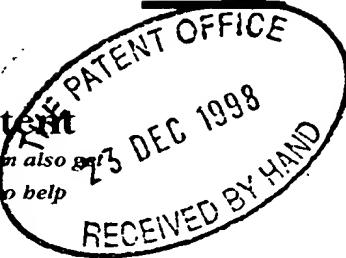
The Patent Office

Cardiff Road
Newport
Gwent NP9 1RH

1.	Your reference	PAT 98031 GB	

2.	Patent application number *(The Patent Office will fill in this part)*	23 DEC 1998	**9828544.8**

3. Full name, address and postcode of the or of
each applicant *(underline all surnames)*

NOKIA MOBILE PHONES LIMITED
KEILALAHDENTIE 4
02150 ESPOO
FINLAND

Patents ADP number *(if you know it)*

If the applicant is a corporate body, give the
country/state of its incorporation

FINLAND 311 1950...

4. Title of the invention

IMAGE SENSOR

5. Name of your agent *(if you have one)*

"Address for service" in the United K
to which all correspondence should   Nokia IPR Department   ED
(including the postcode)   Nokia House, Summit Avenue
Southwood
Farnborough
Hampshire
GU14 0NZ

Patents ADP number *(if you know it)*

		Country	Priority application number *(if you know it)*	Date of filing *(day / month / year)*
6.	If you are declaring priority from one or more earlier patent applications, give the country and the date of filing of the or of each of these earlier applications and *(if you know it)* the or each application number			

		Number of earlier application	Date of filing *(day / month / year)*
7.	If this application is divided or otherwise derived from an earlier UK application, give the number and the filing date of the earlier application		

8. Is a statement of inventorship and of right
to grant of a patent required in support of
this request? *(Answer 'Yes' if:*   YES
a) any applicant named in part 3 is not an inventor, or
b) there is an inventor who is not named as an
applicant, or
c) any named applicant is a corporate body.
See note (d))

Patents Form 1/77

9. Enter the number of sheets for any of the following items you are filing with this form. Do not count copies of the same document

Continuation sheets of this form

Description 9

Claim(s) 2

Abstract 1

Drawing(s) 2 + 2

10. If you are also filing any of the following, state how many against each item.

Priority documents

Translations of priority documents

Statement of inventorship and right to grant of a patent *(Patents Form 7/77)* 1

Request for preliminary examination and search *(Patents Form 9/77)* 1

Request for substantive examination *(Patents Form 10/77)*

Any other documents *(please specify)*

11.

I/We request the grant of a patent on the basis of this application.

Signature

JULIET JANE GRACE HIBBERT

Date

12. Name and daytime telephone number of person to contact in the United Kingdom

DHIREN PATEL 01276 419 545

Warning

After an application for a patent has been filed, the Comptroller of the Patent Office will consider whether publication or communication of the invention should be prohibited or restricted under Section 22 of the Patents Act 1977. You will be informed if it is necessary to prohibit or restrict your invention in this way. Furthermore, if you live in the United Kingdom, Section 23 of the Patents Act 1977 stops you from applying for a patent abroad without first getting written permission from the Patent Office unless an application has been filed at least 6 weeks beforehand in the United Kingdom for a patent for the same invention and either no direction prohibiting publication or communication has been given, or any such direction has been revoked.

Notes

a) If you need help to fill in this form or you have any questions, please contact the Patent Office on 0645 500505.

b) Write your answers in capital letters using black ink or you may type them.

c) If there is not enough space for all the relevant details on any part of this form, please continue on a separate sheet of paper and write "see continuation sheet" in the relevant part(s). Any continuation sheet should be attached to this form.

d) If you have answered 'Yes' Patents Form 7/77 will need to be filed.

e) Once you have filled in the form you must remember to sign and date it.

f) For details of the fee and ways to pay please contact the Patent Office.

Patents Form 1/77

Image Sensor

The present invention relates to video image sensors, and more particularly to colour and light sensing in relation to such sensors.

Red, green and blue (RGB) are three primary additive colours whereby individual components are added together to form a desired colour and this format is the basic colour space model which is widely used throughout imaging. In particular, broadcast, video and imaging standards make use of RGB signals to derive luminance and colour difference video signals, such as YUV, YIQ or YCbCr colour spaces. Colour spaces are mathematical representations of a set of colours. In YUV, Y represents the black and white information in the video signal (i.e. luminance), and U and V represent the colour information in the video signal (i.e. chrominance). The basic equations for converting between RGB and YUV are:

$$Y = 0.299R + 0.587G + 0.114B$$
$$U = -0.147R - 0.289G + 0.436B$$
$$U = 0.492(B - Y)$$
$$V = 0.615R - 0.515G - 0.100B$$
$$V = 0.877(R - Y)$$

In YIQ colour space, I stands for in-phase and Q stands for quadrature, which is the modulation method used to transmit the colour information; YIQ can be derived from YUV. YCbCr is a scaled and offset version of the YUV colour space.

Currently, in known colour video sensing devices such as video cameras, black and white pixel sensors are adapted to read colour information by disposing colour filters over the sensors, which sensors typically are CCD or

CMOS sensors. A standard arrangement is for the pixels to be grouped in 2 x 2 blocks, with diagonally opposite pixels being responsive to green light and the other two diagonally opposite pixels being responsive to blue and red light respectively. These are known as RGB filters. The reason why there are two

5   green pixels is that more image information is present in green light.

It has been noted that a problem of using such an arrangement of RGB filters is that it introduces a light attenuation of approximately 50:1. The share of the pixels between green, blue and red filters means that there is only 25% of the

10   black and white pixel sensors for each of the blue and red filters, and 50% for the green filters. The result is that the sensor loses a great deal of colour resolution. Attempts are made in the downstream processing of the sensor output to recover the original resolution and a common technique is interpolation of the sensor output information using complex proprietary

15   algorithms. This in essence involves estimating by interpolation what the colour response might be at a given pixel location based on the sensor outputs from the pixels surrounding that given pixel. However, since interpolation is a very approximate calculation its effectiveness varies widely depending on the complexity of the algorithm.

20

In addition, use of RGB filters leads to a reduction in sensitivity. Furthermore, there is also a reduction in the spatial resolution of the sensor, RGB colour filtering reducing resolution approximately by a factor of four.

25   A solution to the problem of loss of sensitivity due to RGB filters is to increase the length of time that the sensors are exposed to the scene to be captured on video. However, the knock-on effect of this is that the camera is more susceptible to shaking, and also blurring due to subject movement is more likely to occur. This is a particularly marked problem for CMOS sensors

30   which are of much lower sensitivity than CCD sensors. Also, since sensor

noise is additive, longer exposure periods results in higher noise floor, and thus the image signal is swamped.

As mentioned previously, in general, resolution of the image is determined by interpolation. Since there are a greater number of pixels in the green colour band and since also green light contains greater image information, this is used to increase the effective resolution of red and blue sensors. The main problem with this technique is that it is highly dependent on the quality of the algorithm used and its complexity. Sometimes the quality of the red and blue information can be improved further using green information.

The present invention is based on the observation that the human eye is not as sensitive to colours as it is to brightness. In light of this observation, it is proposed that instead of at the pixel level having red, green and blue filters mapping onto respective pixels, certain of the colour pixels be replaced by so-called 'grey' filters in which there are no colour filters associated with such pixels. Accordingly, the present invention resides in an image sensing device having an array of image sensors and a filter structure disposed in relation to the image sensors, the filter structure comprising blocks of filter groups, each group having a combination of one or more areas adapted so as to allow light to pass therethrough onto corresponding image sensors with colour filtering, and one or more areas adapted so as to allow light to pass therethrough onto corresponding image sensors without colour filtering.

A key advantage of the present invention, is that because there are certain areas in the filter which will allow the incident light to pass through without any colour filtering, the attenuation of the light is greatly reduced and consequently sensitivity of the device is enhanced compared with known RGB filter image sensing devices.

A further advantage of the present is that it is better suited to image compression because it provides for better compatibility with such compression techniques. This is because image compression systems such as MPEG and JPEG have similar luminance and chrominance requirements

5   to that output from the sensors of the present invention. In particular, such compression standards reduce chrominance, while sustaining the same level of luminance. Because the grey resolution and colour resolution of an image sensor of the present invention is designed to match those of MPEG and JPEG compression standards, the signals output from the sensors require a

10   minimal amount of additional signal conditioning for JPEG and MPEG compression.

A further advantage is that since there is a direct measure of luminance by virtue of those areas of the filter where there are no colour filters, the grey

15   pixels of the present invention offer a full resolution of the image and therefore there is a significant improvement in image quality.

Additionally the image sensor calculation of YUV is much simplified over known prior art systems.

20

The present invention will now be described by way only of example with reference to the accompanying drawings in which:

Figure 1 schematically illustrates a first embodiment of the present invention;

25   Figure 2 schematically illustrates a second embodiment of the present invention; and

Figure 3 schematically illustrates a third embodiment of the present invention.

Referring initially to Figure 1, there is shown a filter group of a unitary block

30   (10) from a repeating pattern of such blocks forming a filter structure in

accordance with a first embodiment of the present invention. The filter structure is overlaid in relation to an array of pixel sensors of a video imaging device. The block (10) consists of six filter areas. Four of these are areas in which there are no colour filters overlaying the respective pixels and these are

5   denoted Y (for ease of reference these will be referred to as grey sensors). There is one area denoted B which represents a blue filter and there is another area denoted R which represents a red filter. The Y areas conveniently are formed by apertured windows in the filter structure which align with respective pixels sensors. In this embodiment the Y areas are

10   generally square, although rectangular and other shapes are equally permissible, and they are arranged spaced from one another in a generally square configuration. The blue and red filters are disposed centrally in relation to the four square grey sensors and conveniently are triangular in shape, although again other shapes are equally permissible.

15

The process involved in capturing a video image using the filter structure of the present invention begins by first starting exposure for the red and blue filters. As mentioned above, since chrominance filters are less sensitive to light than luminance filters it is necessary to expose them for longer exposure

20   times than luminance filters. Sensor readings are then taken from the four grey sensors by sampling them. While reading the luminance response the chrominance filters are subjected to extended exposure time. Next, the red and blue pixels are sampled. This series of steps is repeated for each block and involves reading a row of pixel sensors, resetting and looping. Typically,

25   the refresh rate is 30 frames per second and is sequential.

Since in known RGB arrangements the green filters occupy 50% of the filter space in a 2 x 2 block, it is proposed that in this embodiment the Y areas also occupy half of the filter space in a block, and because there are a group of

30   four Y areas in each block, this can be expressed as fraction 4/8 of the overall

filter space in each block. As there is no colour filtering in these Y areas the grey sensors are 50 times more sensitive and thus the overall sensitivity of the block is increased by 4/8 x 50 giving 25 times the sensitivity of prior art RGB filters. It should be mentioned that in order to achieve the same overall

5   area of filter block as RGB filters, as there are four Y areas in place of two green filters, the size of each of the Y areas is reduced by 50% in comparison to green filters.

It was explained above that the blue and red pixels have four times the

10   exposure time and this produces four times the amplitude. Effective sensitivity will therefore be increased fourfold and thus could allow for a reduction in filter size over known blue and red filters.

So for this embodiment, the relative areas are four Y areas each at 1/8 of the

15   overall size, one blue at 2/8 of the overall area and one red pixel again at 2/8 of the overall area. YUV is then given by the following set of equations:

Luminance for pixel 1	$Y1 = Grey1 - 2R - 3B$
Luminance for pixel 2	$Y2 = Grey2 - 2R - 3B$
Luminance for pixel 3	$Y3 = Grey3 - 2R - 3B$
Luminance for pixel 4	$Y4 = Grey4 - 2R - 3B$
Blue chrominance	$U = 3B - (grey1 + grey2 + grey3 + grey4)/8$
Red chrominance	$V = 6R - 0.9 \times (grey1 + grey2 + grey3 + grey4)/4$

20 (row label)

25 (row label)

The reduction in signal amplitude for red and blue pixels is not significant, with 1/6 of full scale 12 bit (256), providing A/D values 0 to 42; this is particularly so given that image compression algorithms reduce resolution below this during quantisation. However, to correct for this there could be an increase in

30   size of red and blue pixels, and for example doubling their filter areas would

increase A/D range to 84 and affect sensitivity by 16 times that of standard RGB filtered sensors.

The above estimates are model values ignoring fill factor, which is concerned with the amount of associated silicon in the sensor chip dedicated to processing and which will effectively reduce as a result of this method. If grey pixels are same size as black/white, and fill factor is 25% for the latter, then the table below outlines the unit area for each sensor block.

	black/white		GreyRB
Pixels	4		8
Associated local circuitry	12	1	8
Total area for GreyRB	16		26
Absolute fill factor	25%		31%
Corrected fill factor*	15%		

* allowing for the fact that only four of the eight pixels are for luminance

Therefore 25 fold increase in sensitivity is likely to be 15%/25% x 25 = 15:1 increase in sensitivity. The likely increase in silicon could be 26/16 times the size, ie. 62% larger. However, the sensor array is only around 50% of the total silicon area, and therefore this equates to a 31% area increase.

Figure 2 illustrates an alternative embodiment in which the red and blue filters of the block (20) are provided in strip like bands separating pairs of Y areas disposed above and below the bands. It is envisaged that the manufacture of such a filter structure would be much simplified because the ease of forming the red and blue bands would be increased because of less stringent alignment requirements of colour filters in relation to the pixel sensors. The

manner in which this embodiment works is similar to the embodiment of Figure 1, although because of the different filter structure the specific mathematics of the filter sizes and sensitivity calculations are different. Such calculations being readily derivable by those skilled in the art based on the

5   equations provided above.

A third embodiment (30) of the present invention is illustrated in Figure 3. In this embodiment green (34) and red (32) stripped filters are disposed lengthwise across the Y areas (and grey pixels) which are disposed in a

10 generally square configuration as in the previously described embodiments. This embodiment is similar to that of either of Figures 1 or 2 in that for each block there are four grey sensors disposed in a square configuration around centrally disposed red and blue colour filters, the addition being that of the green and red stripped filters across the Y areas. Whilst the grey sensors in

15 this embodiment still take a direct measure of luminance they are corrected for red and blue by the green and red strips and therefore provide a measure of luminance without the need for any calculation as required in embodiments for Figure 1 and 2. In other words, the green and blue strips correct for the influence of the central red and blue filters and accordingly yield direct Y

20 measurements.

The present invention may be embodied in other specific forms without departing from its essential attributes. For example, different specific configurations of the various colour/non-colour areas are possible giving

25 analogous results. Accordingly reference should be made to the appended claims and other general statement's herein rather than to the foregoing specific description as indicating the scope of invention.

Furthermore, each feature disclosed in this specification (which term includes

30 the claims) and/or shown in the drawings may be incorporated in the invention

independently of other disclosed and/or illustrated features. In this regard, the invention includes any novel features or combination of features disclosed herein either explicitly or any generalisation thereof irrespective of whether or not it relates to the claimed invention or mitigates any or all of the problems

5 addressed.

The appended abstract as filed herewith is included in the specification by reference.

Claims

1.   An image sensing device having an array of image sensors and a filter structure disposed in relation to the image sensors, the filter structure comprising blocks of filter groups, each group having a combination of one or more areas adapted so as to allow light to pass therethrough onto corresponding image sensors with colour filtering, and one or more areas adapted so as to allow light to pass therethrough onto corresponding image sensors without colour filtering.

2.   An imaging device according to claim 1, wherein said one or more areas adapted so as to allow light to pass therethrough onto corresponding image sensors with colour filtering comprise two colour filters.

3.   An imaging device according to claim 2, wherein the two colour filters are one each of red and blue filters.

4.   An imaging device according to any preceding claim, wherein said one or more areas adapted so as to allow light to pass therethrough onto corresponding image sensors without colour filtering comprise four filterless areas.

5.   An imaging device according to any preceding claim, wherein said one or more areas adapted so as to allow light to pass therethrough onto corresponding image sensors without colour filtering comprise four non-colour filters.

6.   An imaging device according to any preceding claim, wherein the arrangement of said areas in each block of filter groups in the filter structure comprises stripline formation of said respective areas.

7. An imaging device according to any preceding claim, wherein the image sensors are CMOS sensors.

5 8. An imaging device according to any to any preceding claim, wherein said one or more areas adapted so as to allow light to pass therethrough onto corresponding image sensors without colour filtering include one or more colour filters disposed at least partially thereover.

10 9. An imaging device according to claim 8, wherein said one or more colour filters disposed over the one or more areas adapted to allow light to pass therethrough without colour filtering comprise colour filter strips.

10. An image sensing device according to any preceding claim, wherein 15 said colour filtering areas are disposed centrally in the filter group and said areas without colour filtering are disposed in a generally square like configuration around the central colour filters.

11. An imaging device having a filter structure substantially as herein 20 before described with reference to and as shown in the accompanying drawings.

12. A filter structure substantially as herein before described with reference to and as shown in the accompanying drawings.

Abstract

This invention discloses a filter structure for a video image sensing device. The filter structure consists of a red colour filter and a blue colour filter and these are combined in a sensing block with non-colour or apertured windowed sensors i.e. grey sensors.
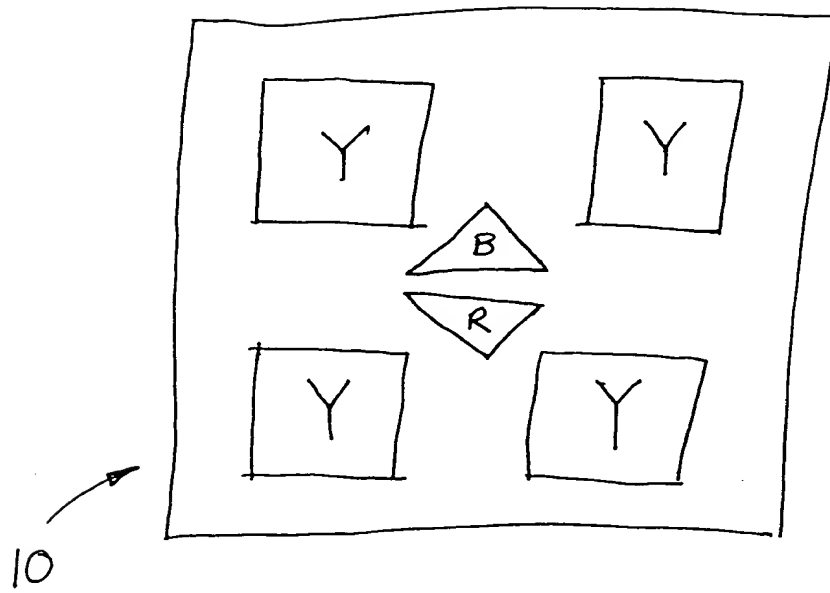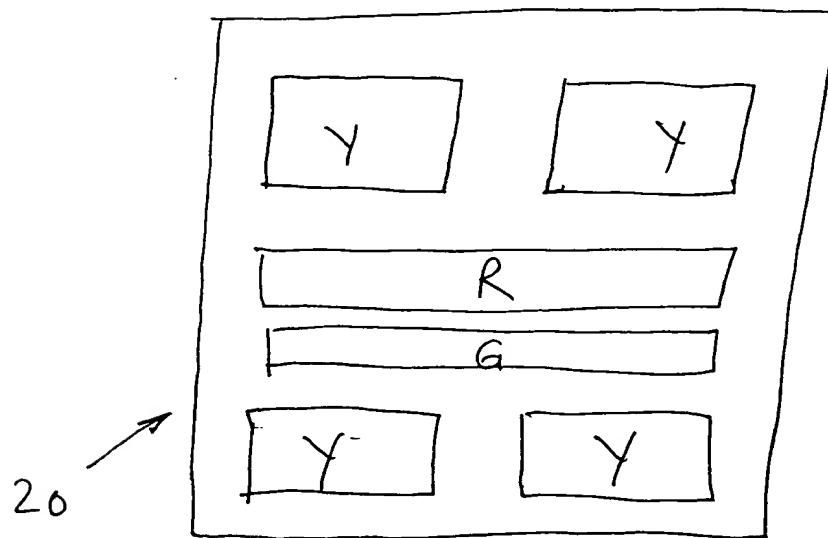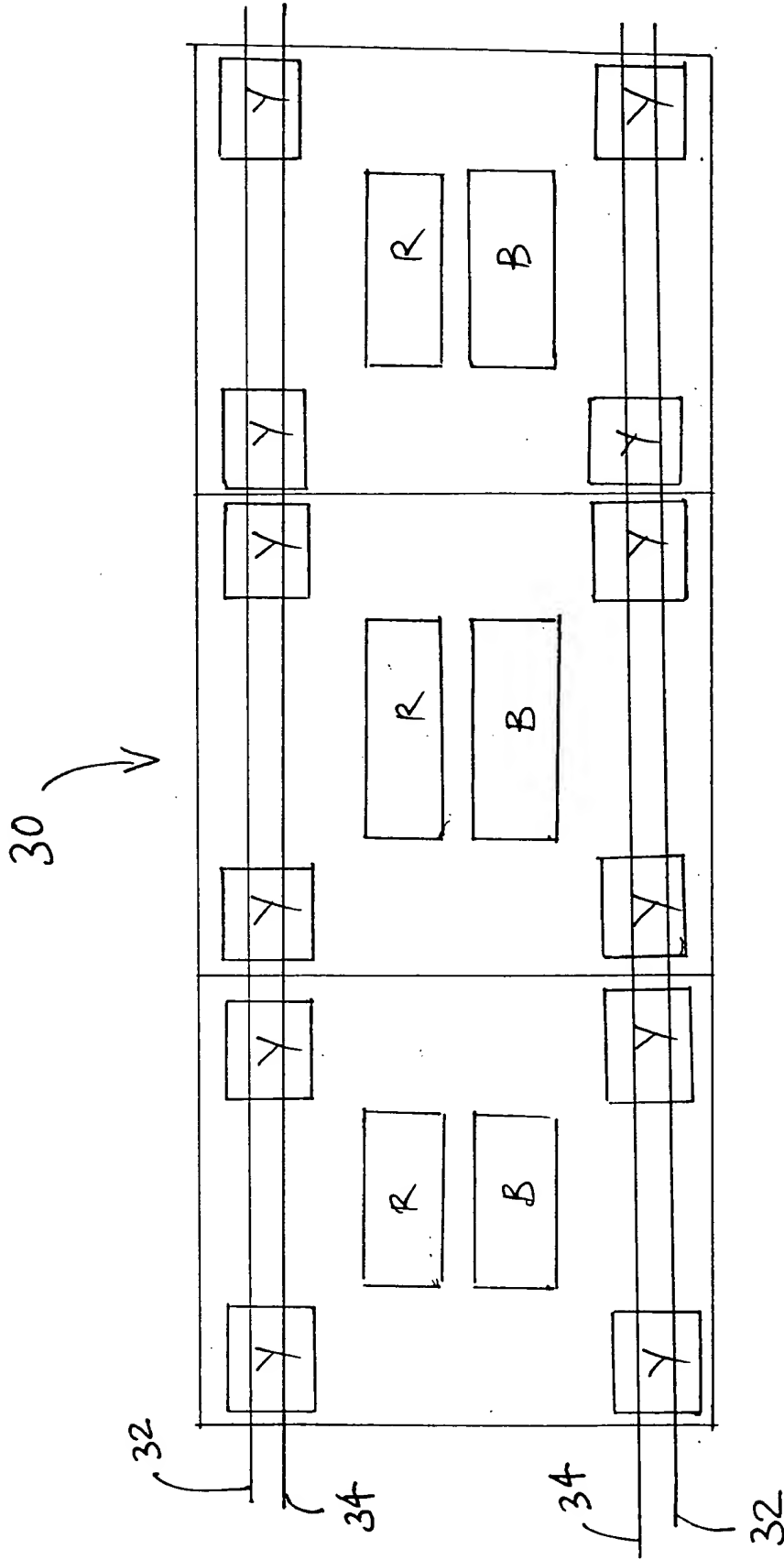
Figure Number 1

FIG 1

FIG2

FIG 3